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REPORT ON POLLUTION OF INTERSTATE WATERS OF THE NORTH FORK HOLSTON RIVER AND OF HOLSTON AND TENNESSEE RIVERS, VIRGINIA - TENNESSEE

ROBERT A. TAFT SANITARY ENGINEERING CENTER
CINCINNATI, OHIO

SEPTEMBER 1960

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REPORT ON

POLLUTION OF INTERSTATE WATERS

of the

NORTH FORK HOLSTON RIVER

and of

HOLSTON AND TENNESSEE RIVERS

VIRGINIA - TENNESSEE

U. S. Department of Health, Education, and Welfare
Public Health Service
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

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16. Abstracts Information regarding wastes discharged into the North Fork of the Holston River by the Olin Mathieson Chemical Corporation is presented. The watershed is described, water uses identified, and effects of pollution on water quality are discussed. Economic losses attributed to pollution of the Holston River system are summarized.

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VIRGINIA-TENNESSEE
SEPTEMBER 1960

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21	4	5	mg/l	mgs
26	3	2	Rogersville	Church Hill

REPORT ON POLLUTION OF INTERSTATE WATERS
OF THE NORTH FORK HOLSTON RIVER AND OF HOLSTON
AND TENNESSEE RIVERS - VIRGINIA-TENNESSEE

BACKGROUND

In 1894 the Mathieson Alkali Works was established at Saltville, Virginia, on the North Fork Holston River in southwestern Virginia. Since that time the plant has continuously produced soda ash from the extensive underground salt deposits by the ammonia-soda process.

This operation has led to a stream pollution problem of long duration. Evidence of the continuing problems attributed to this operation is contained in voluminous files of the state health departments and the stream pollution control agencies of both Virginia and Tennessee dating back to at least 1924.

In late 1924 the problem was dramatically brought to the attention of numerous agencies and individuals when the dike of the lagoon in which calcium and sodium chloride wastes were stored broke and released a tremendous slug of wastes to the North Fork Holston River. The effects of this accident were felt as far as the Chattanooga, Tennessee, water plant some 425 miles downstream.

Although the waste lagoon has been reinstalled on a sound engineering basis and controlled discharge of the wastes in proportion to the flow of North Fork Holston River has been improved in recent years, complaints regarding the effects of these wastes on water uses have continued to the present.

A major fish kill in the North Fork Holston River below Saltville, in late 1946, brought the pollution problem to the attention of the newly formed Virginia Water Control Board. Negotiations between the Water Control Board and company officials were initiated shortly thereafter and continued at intervals from

then until January, 1960. Three official hearings on the problem were held during the period 1953 through 1956 and there have been numerous appearances of representatives of the company before the Board since that time.

On December 13, 1956, the Virginia Control Board issued a special order to the company. This order specified, among other things, that the company should take steps to hold chloride concentrations in the North Fork Holston River below a maximum of 5,000 p.p.m. and that the company should present evidence to show why it was not feasible to reduce the wastes discharged by:

1. Evaporation and recovery of calcium chloride.

2. Conversion of at least a portion of the manufacturing process to electrolytic production of sodium hydroxide and chlorine.

3. Provision of additional settling capacity.

About three years later, in January 1960, the company presented evidence to show that it had complied with the special order of the Water Control Board in regard to maintenance of chloride concentrations not in excess of 5,000 p.p.m. Additional evidence was presented to show that none of the suggested methods for reduction in total chlorides was feasible. The evidence included a statement that underground disposal of the wastes in the Saltville area likewise was not feasible.

The technical staff of the Water Control Board stated that they had considered the company's evidence and had concluded there were no feasible methods presently available for significant reduction of the wastes short of closing down the plant.

On May 31, 1960, the Tennessee Stream Pollution Control Board requested the U. S. Public Health Service to hold a conference on pollution of the interstate waters of North Fork Holston River under the provisions of Public Law 660.

This report presents information regarding: the wastes discharged by the plant of the Olin Mathieson Chemical Corporation

(formerly The Mathieson Chemical Corporation) to the North Fork Holston River at Saltville, Virginia; uses of the waters of the North Fork Holston River and of the Holston and Tennessee rivers as far downstream as Lenoir City, Tennessee, about 275 stream miles below Saltville; and effects of the wastes on water uses.

THE AREA

The area dealt with in this report is shown in Figure 1, which includes the streams involved, the points on the streams at which principal sources of analytical data are available, and principal points at which water is withdrawn for municipal and industrial uses.

The North Fork Holston River rises in Bland County, Virginia, and flows in a generally southwesterly direction to the Virginia-Tennessee state line near Kingsport, Tennessee. The river crosses the state line about 4.5 miles above its confluence with the South Fork Holston River, where the Holston River is formed. The distance from this confluence of the stream to Saltville is 82 miles. The Holston River flows in a generally southwesterly direction for 142 miles to Knoxville, Tennessee, where it joins the French Broad River to form the Tennessee River. The Tennessee River flows past Knoxville in a generally southwesterly direction to Lenoir City, Tennessee, which is 52 miles below the confluence of the Holston and French Broad Rivers.

Four major reservoirs exert direct effects on stream flows in portions of the stream system under consideration.

Fort Patrick Henry Reservoir on the South Fork Holston River, just above Kingsport, controls the flow of the South Fork and has an important bearing on dilution of the highly mineralized waters of the North Fork.

Cherokee Reservoir impounds about one-third of the length of the Holston River and controls the flow of the Holston at its confluence with the French Broad River, about 52 miles below Cherokee Dam. This reservoir provides long-time storage of the water and accomplishes considerable equalization of upstream variations in water quality.

Douglas Reservoir on the French Broad River, with its dam about 30 miles above the mouth, controls the flow of the French Broad at its confluence with the Holston River. Control of flows by this reservoir and by Cherokee Reservoir has an important bearing on the relative proportions of the two rivers that combine to form the Tennessee River. This control exerts an important effect on

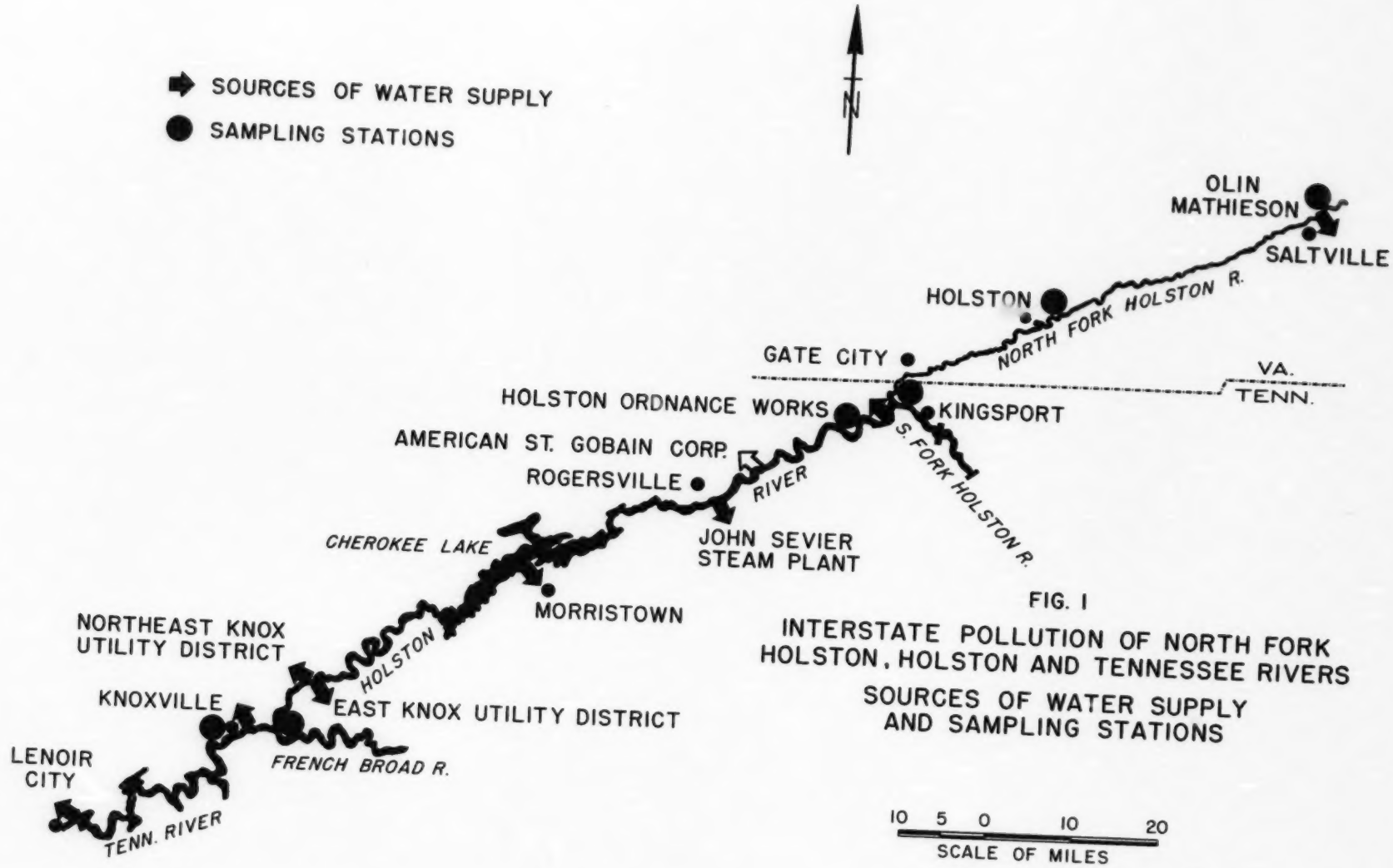

FIG. 1

INTERSTATE POLLUTION OF NORTH FORK HOLSTON, HOLSTON AND TENNESSEE RIVERS

SOURCES OF WATER SUPPLY AND SAMPLING STATIONS

water quality at the Knoxville Water Plant intake.

Fort Loudoun Reservoir, between Knoxville and Lenoir City, provides relatively short-term storage of the Tennessee River and controls its flow at Lenoir City.

Water uses of the streams involved include:

1. Municipal water supply.
2. Industrial water supply.
3. Recreation.
   a. Fishing.
   b. Boating.
   c. Swimming.
4. Power production.
5. Navigation.
6. Agriculture.
   a. Stock watering.
   b. Supplemental irrigation.
7. Waste disposal.

WATER USES

All reaches of the streams involved are used or, in the absence of interference by pollution, are potentially useful for swimming, fishing, boating, stock watering, and supplemental irrigation.

Municipal water supplies taken from the streams involved serve the following jurisdictions:

1. Holston River.
    a. Morristown, Tennessee.
    b. Northeast Knox Utility District.
    c. East Knox Utility District.
2. Tennessee River.
    a. Knoxville, Tennessee.
    b. Lenoir City, Tennessee.

Major industrial water supplies taken directly from the streams are used by the following industries:

1. North Fork Holston River.
    a. Olin Mathieson Chemical Corporation, Saltville, Virginia.
2. Holston River.
    a. Holston Ordnance Works, Kingsport, Tennessee.
    b. TVA, John Sevier Steam Plant, Rogersville, Tennessee.

3. Tennessee River.

a. TVA, Watts Bar Steam Plant,
Lenoir City, Tennessee.

The American St. Gobain Corporation, Greenland Plate Glass Plant, is being constructed on the Holston River between Church Hill and Surgoinsville, Tennessee and proposes to take its water supply from the Holston River.

In addition, there are numerous industries in Morristown, Knoxville, and Lenoir City which take their water supplies from the municipal systems.

Power is produced at Cherokee Dam on the Holston River and at Fort Loudoun Dam on the Tennessee River.

Navigation is an important use of Fort Loudoun Reservoir on the Tennessee River.

SOURCES OF INORGANIC POLLUTANTS

The Olin Mathieson Chemical Corporation plant at Saltville produces soda ash by the ammonia-soda process. The principal waste from this process contains large quantities of calcium and sodium chlorides. These constituents have led to complaints of stream pollution downstream from Saltville. In subsequent discussion of the effects of the wastes consideration will be given to calcium as reflected in hardness (expressed as $CaCO_3$), to chlorides, and to sodium.

All of these constituents are contained to some extent in most natural surface waters. Hardness may range between 10 and 200 mg/l in the tributary streams of the watersheds involved. In general, waters of the tributaries originating in the mountainous areas to the East tend to be quite soft, while those from the central and western portions of the watershed generally are much harder. Chlorides and sodium in the tributary waters usually are quite low and average only a few mg/l, regardless of the areas in which the tributaries originate.

For convenience in presenting the data, the three constituents may be assigned to six principal sources:

1. Olin Mathieson Chemical Corporation, Saltville, Virginia.
2. North Fork Holston River, above Saltville, Virginia.
3. Tributaries of the North Fork Holston River, Saltville to mouth.
4. South Fork Holston River.
5. Tributaries of the Holston River, confluence North and South forks to mouth.
6. French Broad River.

Table 1 presents the quantities of hardness as $CaCO_3$, chlorides as Cl, and sodium as Na, in pounds per day from the six principal sources. These data also are presented in Figure 2.

These data are based on stream analyses made principally during the five-year period, 1952 through 1956. This period was selected because of the excellent five-year record of analyses of water from the North Fork Holston River at Holston, Virginia, which is available in publications of the U. S. Geological Survey. Most of the analytical results which were used for other sampling stations on the river system were obtained during the same period.

In Table 1 the quantities of these materials are totalled for the Tennessee River at the Knoxville Water Plant intake, and percentages of these totals for each of the constituents from each source are included.

These percentages show that the Olin Mathieson wastes were the largest single source of each of the three constituents. During the period 1952 through 1956, this plant contributed an average of 1,595,000 pounds per day of hardness, or 26.2 percent of the total at Knoxville; 1,841,000 pounds per day of chlorides, or 84 percent of the total; and 478,000 pounds per day of sodium, or 57.3 percent of the total. The second major source of these constituents at Knoxville was the French Broad River, which accounted for 60 percent of the total flow of the Tennessee River at Knoxville during the period. This source contributed 1,550,000 pounds per day, or 25.5 percent of the total hardness, 232,000 pounds per day, or 10.6 percent of the chlorides, and 265,000 pounds per day, or 31.7 percent of the sodium. Other significant contributions were 22.9 percent of the hardness contributed by the South Fork Holston River, and 18.9 percent of the hardness contributed by tributaries to the Holston River. Contributions of the three constituents from other sources were minor.

TABLE 1

Sources of Hardness, Chlorides and Sodium
Based on Data for 1952 - 1956

	Hardness as $CaCO_3$		Chlorides as Cl		Sodium as Na	
	Lbs./day (in thousands)	Percent of Total	Lbs./day (in thousands)	Percent of Total	Lbs./day (in thousands)	Percent of Total
Olin Mathieson Chemical Corp.	1595	26.2	1841	84.0	478	57.3
North Fork Holston River above Saltville Tributaries,	113	1.9	2.4	0.1	1.6	0.2
Saltville to mouth	281	4.6	5.6	0.3	2.8	0.3
South Fork Holston River	1395	22.9	95.9	4.4	81.2	9.7
Holston River Tributaries	1153	18.9	12.9	0.6	6.4	0.8
French Broad River	1550	25.5	232	10.6	265	31.7
Total(at Knoxville, Tenn.)	6087	100.0	2190	100.0	835	100.0

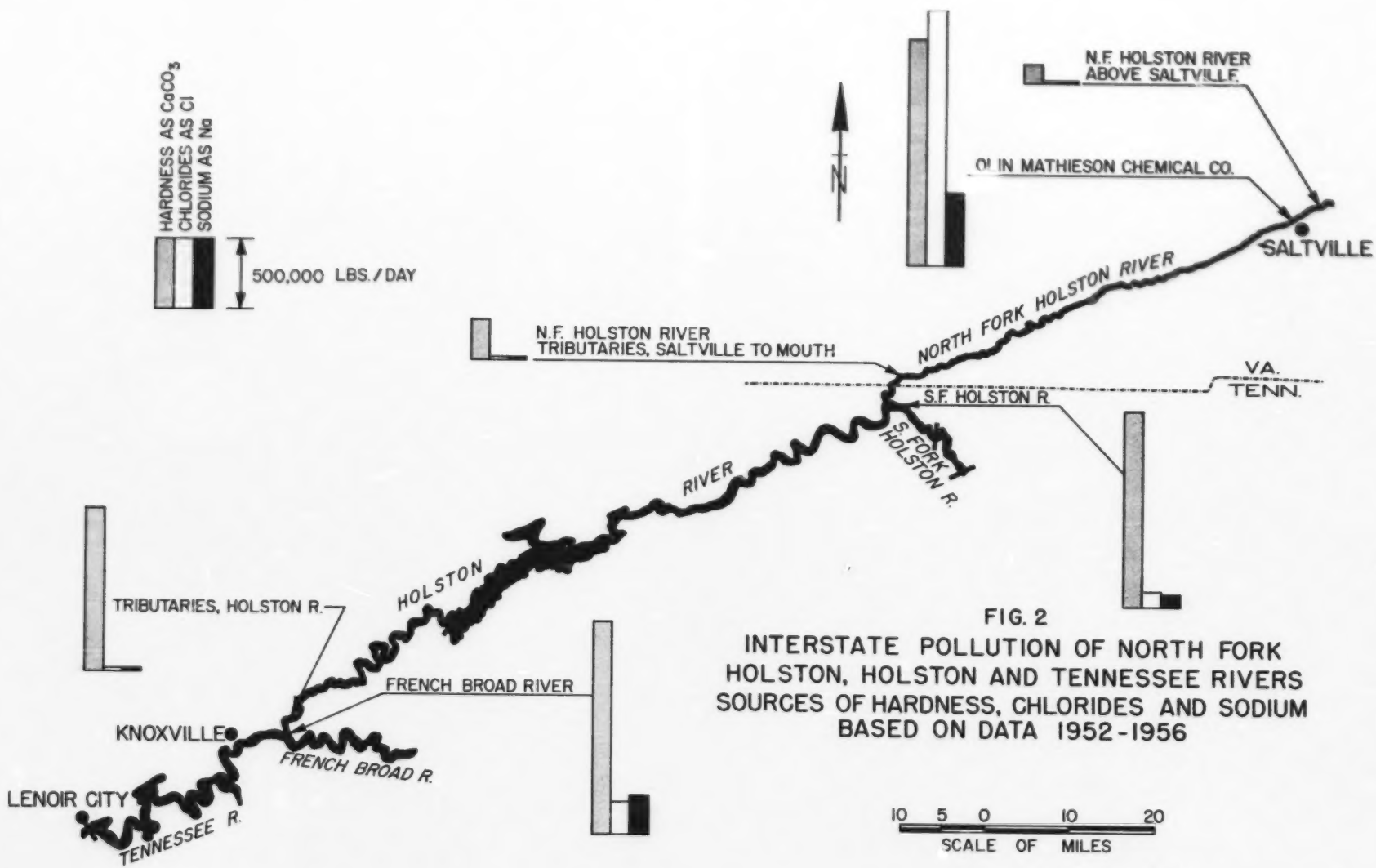

FIG. 2

INTERSTATE POLLUTION OF NORTH FORK HOLSTON, HOLSTON AND TENNESSEE RIVERS SOURCES OF HARDNESS, CHLORIDES AND SODIUM BASED ON DATA 1952-1956

EFFECTS ON WATER QUALITY

Table 2 presents concentrations of hardness, chlorides and sodium at selected points on the river system. Included in the table are percentages of each of the constituents contributed by the Olin Mathieson wastes. The concentrations in this table are averages of actual data at points where analytical data were available. At other points, where analytical data were not available, the concentrations have been computed from the quantities shown in Table 1 and the average stream flows at the selected points in Table 2. Considerable confidence is felt in both the observed and the computed concentrations since they agree very well with values obtained by routing water down the river system from Saltville to Knoxville on a month-to-month basis for the five-year period.

The data are presented also in Figures 3 through 5. Above Saltville the North Fork Holston River had an average hardness of 101 mg/l, an average chloride content of 2 mg/l, and an average sodium concentration of 1.85 mg/l.

Immediately below the waste discharge from the Olin Mathieson plant, the average hardness increased to 2,230 mg/l, chlorides to 2,450 mg/l, and sodium to 611 mg/l.

The concentrations at Holston, Virginia, were 1,825 mg/l of hardness, 2,005 mg/l of chlorides, and 500 mg/l of sodium.

Near Gate City, Virginia, which is about four miles above the Virginia-Tennessee state line, the average hardness was 1,240 mg/l, chlorides were 1,070 mg/l, and sodium was 321 mg/l.

The South Fork Holston River provided approximately a 3 to 1 dilution of the flow of the North Fork and reduced the hardness immediately below their confluence to 216 mg/l, chlorides to 133 mg/l, and sodium to 36 mg/l.

Tributaries of the Holston River provided additional dilution which reduced hardness to 204 mg/l at the mouth of the river, chlorides to 88 mg/l, and sodium to 26 mg/l.

TABLE 2

Average Annual Concentrations of Hardness, Chlorides, and Sodium and Percentages from Olin Mathieson Chemical Corp.

1952 - 1956

LOCATION	RIVER MILE	AVG. ANNUAL FLOW - cfs	HARDNESS(as $CaCO_3$) Total mg/l	%fr.O.M.	CHLORIDES(as Cl) Total mg/l	%fr.O.M.	SODIUM(as Na) Total mg/l	%fr.O.M.
N. Fork Holston R.								
Abv. Saltville, Va.	(NH-81.1)	261	101	0.0	2.0	0.0	1.85	0.0
Blw. Olin Mathieson	(NH-78.1)	261	2230*	93.5	2450*	99.8	611*	99.6
Holston, Va.	(NH-58.1)	465	1825	87.7	2005	99.7	500	99.3
Gate City, Va.	(NH- 8.8)	781	1240	80.2	1070	99.6	321*	98.9
S. Fork Holston R.								
at Mouth	(SH- 0.5)	2150	108	0.0	8.9	0.0	7.0*	0.0
Holston River								
Blw. Confl. N. and S.								
Fk. Holston R.	(H-137.9)	2930	216	47.2	133	94.7	36*	84.8
Rogersville, Tenn.	(H-104.2)	3370	210*	41.8	107*	94.5	31*	84.4
Morristown, Tenn.	(H- 75.2)	3750	207*	38.2	96*	94.3	28*	84.2
at Mouth	(H- 5.5)	4120	204*	35.2	88*	94.1	26*	83.9
French Broad River								
at Mouth	(FB- 7.5)	6120	47	0.0	7.0	0.0	8.0	0.0
Tennessee River								
at Knoxville, Tenn.	(T-649.2)	10,240	106	26.2	39	84.0	15.1*	57.3
at Lenoir City, Tenn.	(T-601.6)	-	106	26.2	39	84.0	15.1*	57.3

* Calculated values.

The soft water of the French Broad River, with an average hardness of 47 mg/l, joins the Holston to form the Tennessee River, about three miles above the Knoxville Water Plant intake. The average hardness of the raw water at the intake was 106 mg/l, the average chlorides were 39 mg/l, and the average sodium was 15.1 mg/l. There is relatively little dilution of the Tennessee River by tributary flow between Knoxville and Lenoir City and it is assumed that the concentrations of the three constituents at the Lenoir City water plant intake are essentially the same as those at the Knoxville intake.

Figures 3 through 5 also indicate the portions of the various concentrations contributed by the Olin Mathieson wastes.

Near Gate City and the Virginia-Tennessee state line, the wastes contributed 80 percent of the hardness. On the Holston River the waste contributed 47 percent of the hardness at the upper end and 35 percent at the mouth of the river. At Knoxville the wastes contributed 26 percent of the hardness.

Near the Virginia-Tennessee state line the Olin Mathieson wastes accounted for 99.6 percent of the chlorides. On the Holston River, the percentages contributed by the wastes dropped slightly from 94.7 percent at the upper end of the river to 94.1 percent at the mouth. At Knoxville Water Plant intake the wastes contributed 84 percent of the chlorides.

Just above the Virginia-Tennessee state line the Olin Mathieson wastes accounted for 98.9 percent of the sodium. In the Holston River the percentages contributed by the wastes dropped slightly from 84.8 percent at the upper end to 83.9 percent at the mouth. At the Knoxville Water Plant intake the wastes accounted for 57.3 percent of the sodium.

The foregoing average concentrations represent only one phase of the total effects of the Olin Mathieson wastes on water quality. In addition to the high concentrations involved, the wide and sometimes rapid fluctuations in concentrations which occurred added to the difficulties involved in treating the water to combat the adverse effects. These fluctuations were caused by

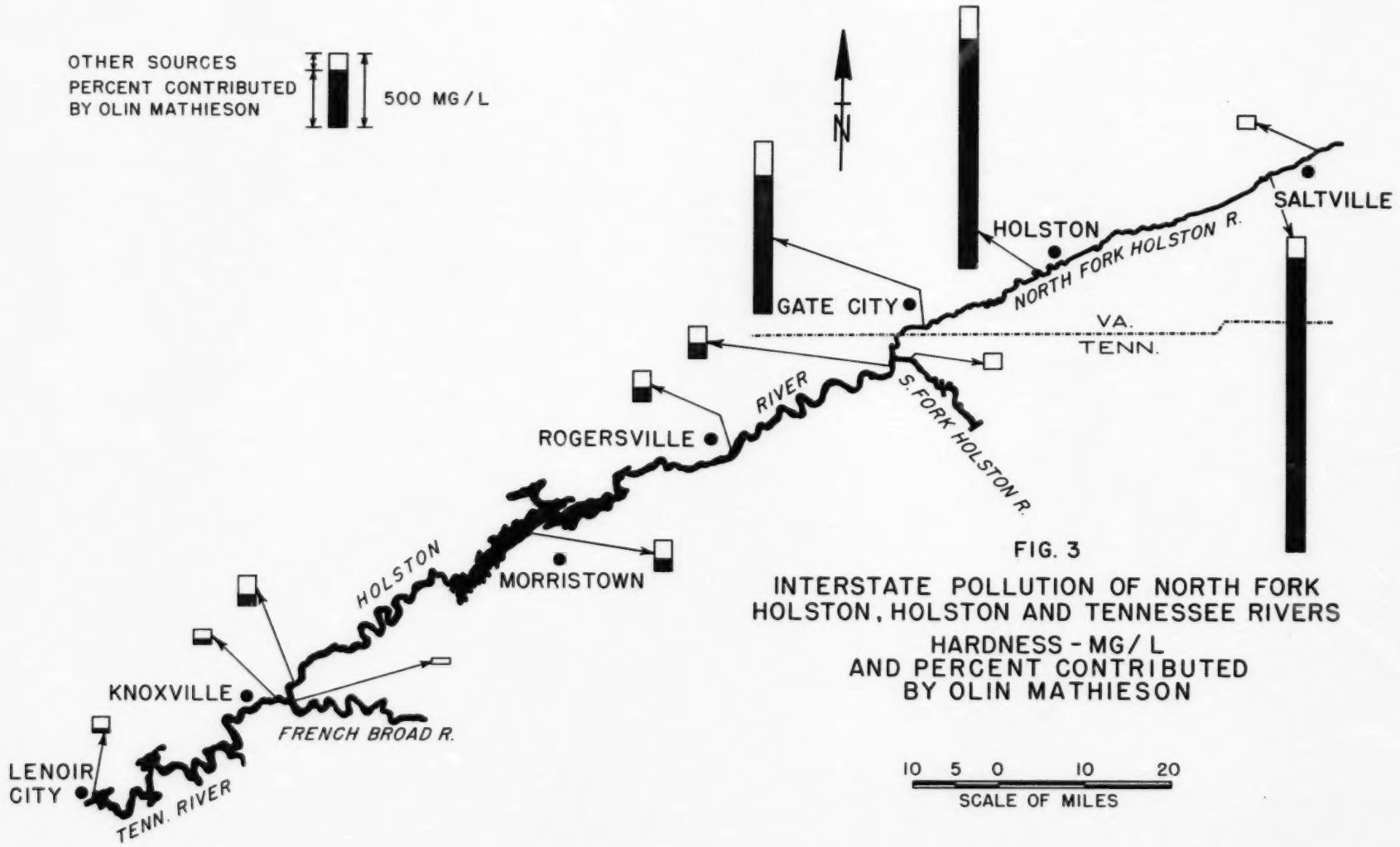

FIG. 3

INTERSTATE POLLUTION OF NORTH FORK HOLSTON, HOLSTON AND TENNESSEE RIVERS

HARDNESS - MG/L
AND PERCENT CONTRIBUTED
BY OLIN MATHIESON

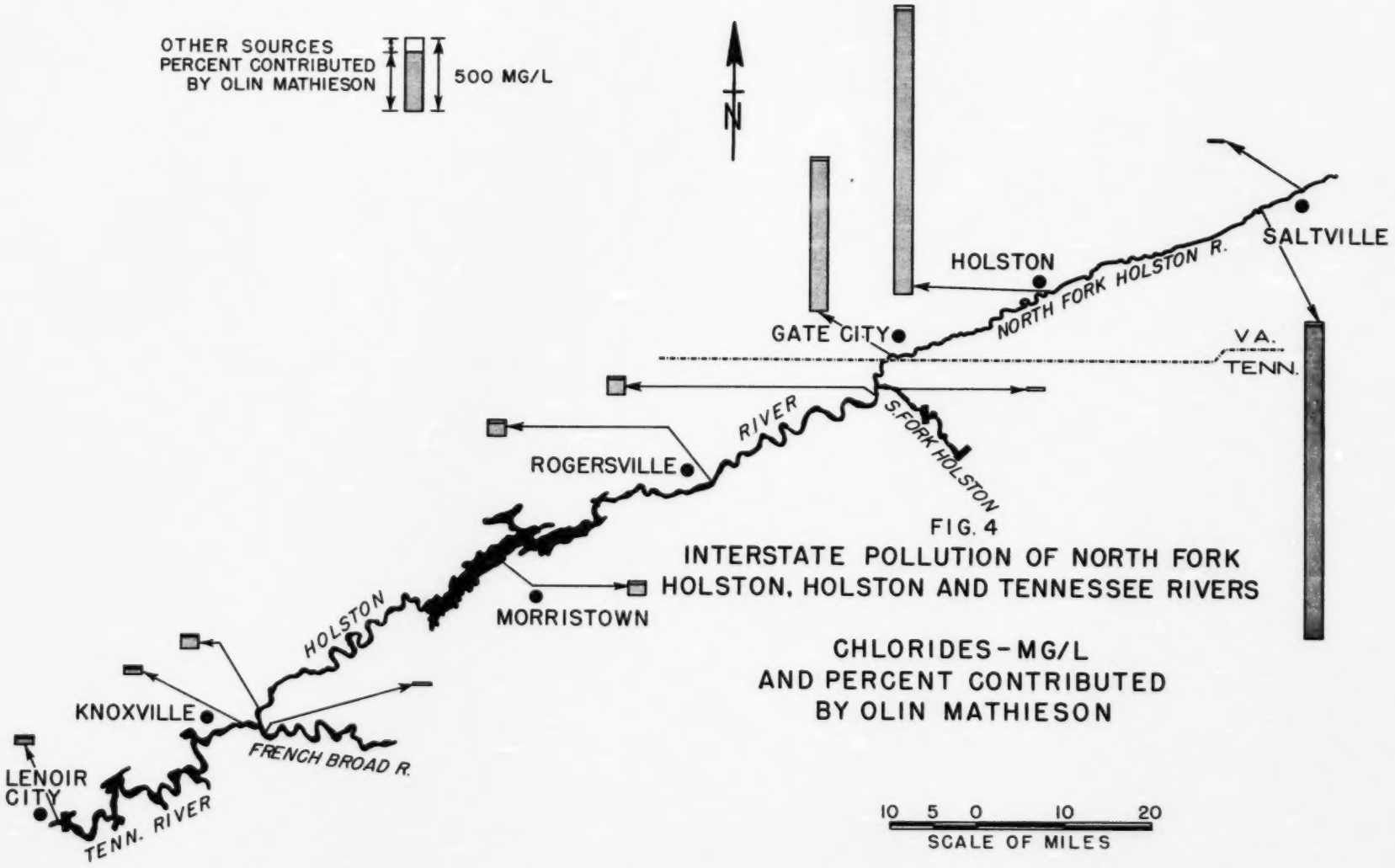

FIG. 4

INTERSTATE POLLUTION OF NORTH FORK HOLSTON, HOLSTON AND TENNESSEE RIVERS

CHLORIDES - MG/L
AND PERCENT CONTRIBUTED
BY OLIN MATHIESON

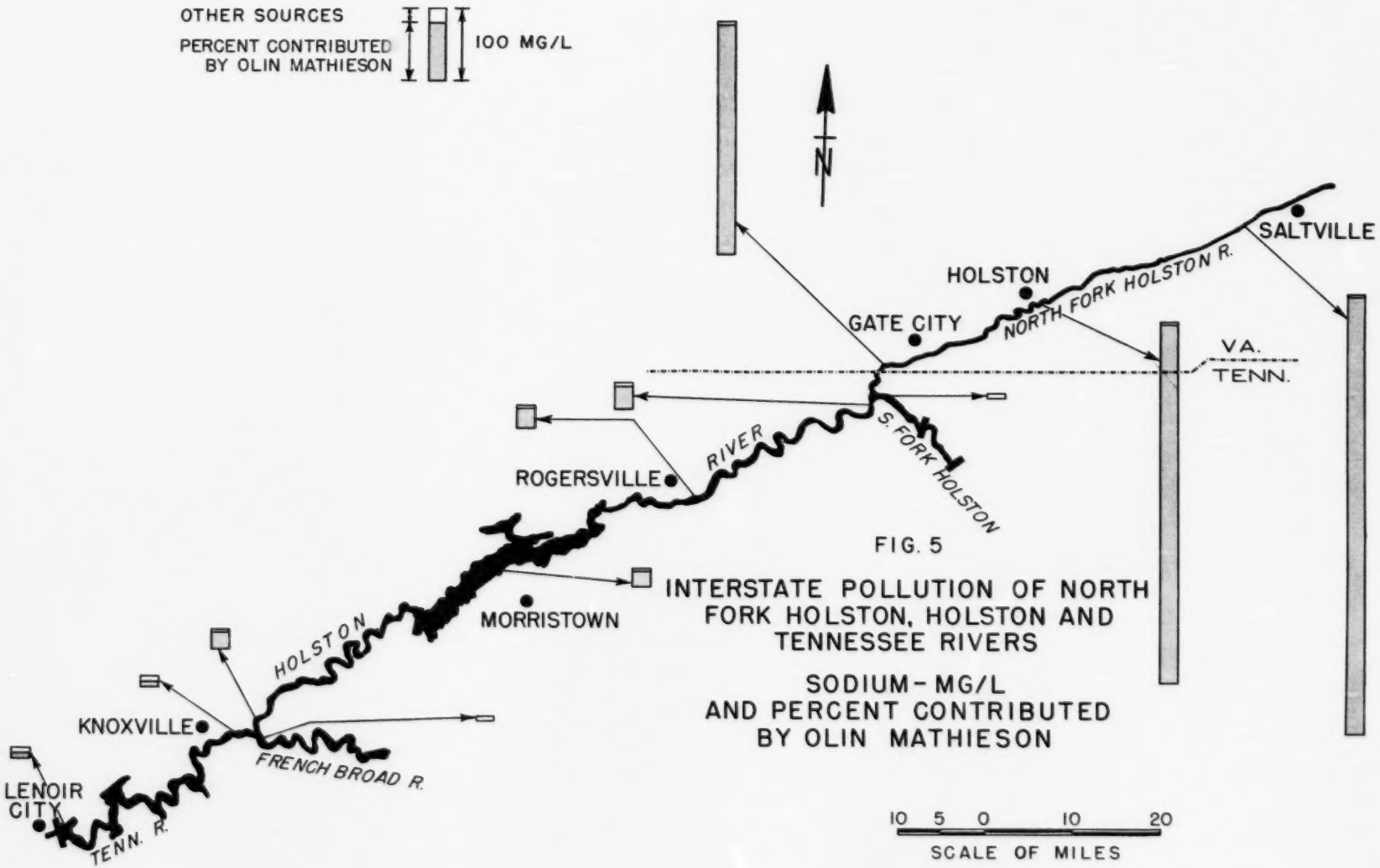

FIG. 5

INTERSTATE POLLUTION OF NORTH FORK HOLSTON, HOLSTON AND TENNESSEE RIVERS

SODIUM - MG/L
AND PERCENT CONTRIBUTED
BY OLIN MATHIESON

natural variations in stream flow of the North Fork Holston River, by variations in discharge of the wastes from the plant, and by the controlled discharges involved in peaking power operations of the Fort Patrick Henry, Cherokee, and Douglas reservoirs. The magnitudes of these fluctuations are illustrated by the following values at selected points.

On the North Fork Holston River at Holston, Virginia, where the hardness averaged 1,825 mg/l during 1952 through 1956, individual values ranged from 108 to 4,870 mg/l. Five percent of the values were in excess of 4,000 mg/l, and twenty-five percent were in excess of 2,900 mg/l. Chlorides, which averaged 2,005 mg/l, varied between 42 and 5,400 mg/l. Five percent of the values were in excess of 4,500 mg/l, and twenty-five percent were in excess of 3,300 mg/l.

On the Holston River, near the upper end, the hardness ranged from 94 to 599 mg/l compared to the average of 216 mg/l. Five percent of the values exceeded 420 mg/l, and twenty-five percent exceeded 240 mg/l. Chlorides varied between 5 and 560 mg/l compared to the average of 133 mg/l. Five percent of the values exceeded 330 mg/l, and twenty-five percent exceeded 170 mg/l. Of especial interest is the fact that twelve percent of the values exceeded 250 mg/l, which is the U. S. Public Health Service recommended limit for chlorides in municipal water supplies. Data on sodium at this point were limited but it is reasonable to assume that the range of sodium around its average of 36 mg/l was similar to the range of chlorides around its average. On this basis sodium would vary approximately in the range of 5 to 100 mg/l.

At the Knoxville Water Plant intake, the hardness ranged from 44 to 219 mg/l compared to the average of 106 mg/l. Five percent of the values exceeded 150 mg/l and twenty-five percent exceeded 126 mg/l. Chlorides ranged between 1 and 140 mg/l compared to the average of 39 mg/l. Five percent of the values were in excess of 79 mg/l and twenty-five percent were in excess of 57 mg/l.

EFFECTS ON WATER USE

GENERAL

Excessive hardness exerts detrimental effects on many uses of water for both municipal and industrial purposes.

The principal effect with respect to municipal supplies is the added cost to domestic consumers for soap and synthetic detergents used in washing and cleaning. In addition, excessive hardness exerts somewhat less tangible effects. It may: interfere with satisfactory laundering of clothes; toughen some boiled vegetables; increase the cost of heating water for household use; decrease the life of cooking utensils; and cause excessive deposits in pipes and in faucets which reduce their carrying capacities. Many consumers in towns having excessively hard municipal supplies soften the water with Zeolite softening equipment.

If a municipality provides water softening at a municipal plant, the city is subjected to additional capital cost and added costs for operation in excess of those necessary for normal coagulation sedimentation, filtration, and disinfection. The calcium chloride hardness discharged to the river system by the Olin Mathieson plant is more expensive to remove by conventional municipal softening processes than is natural calcium bicarbonate hardness. The calcium chloride hardness must be precipitated with soda ash, which is about three times as expensive as the lime used for removal of calcium bicarbonate hardness.

Interferences by excessive hardness of water with industrial processes are many and varied. Probably the single most important interference is the effect on use for boiler-feed water. Preparation of hard water for use in boilers can be quite expensive, especially if the boilers are of the high pressure type. Specific industries which require relatively soft water for manufacturing processes include: textiles, ice manufacturing, soft drink bottling, and vegetable canning.

Excessive chlorides likewise can cause deleterious effects in the use of water for both municipal and industrial purposes.

The U. S. Public Health Service has recommended a limit of 250 mg/l of chlorides in water used for municipal supplies. Concentrations of chlorides in excess of this may impart a salty taste to the water.

In industrial water supplies excessive chlorides may contribute to corrosion of metal equipment with which the water comes in contact. High chlorides are especially objectionable in boilers producing high pressure steam. Specific industries in which excessive chlorides may interfere with the manufacturing process include glass making and metal working.

A high sodium content of water used for municipal purposes may be injurious to persons suffering certain types of heart, liver, and kidney diseases. Some doctors may prescribe that a patient's total daily intake of sodium from all sources must not exceed 500 mg/l. Since it is difficult to limit sodium intake in food to this low value, any significant concentration of sodium in the municipal supply adds to the problem and the patient may be forced to use distilled water. If the patient lives in a home where water is softened by the Zeolite process, the calcium and magnesium portions of the hardness are replaced by sodium, and hardness may contribute indirectly to the over-all problem of maintaining a low sodium diet.

Specific objectives for hardness, chlorides, and sodium have not been adopted officially for the river system by either the Virginia Water Control Board or the Tennessee Stream Pollution Control Board. The staff of the Virginia Water Control Board has suggested, however, that an ultimate chloride objective for the North Fork Holston River at its mouth should be a limit of 125 mg/l. The staff of the Tennessee Stream Pollution Control Board has suggested that hardness in the Holston River should not exceed 100 mg/l, and chlorides should not exceed 50 mg/l.

SPECIFIC EFFECTS

North Fork Holston River below Saltville

Numerous complaints have been submitted to the Virginia Water Control Board involving several miles of the river below the point at which the Olin Mathieson wastes are discharged. These complaints included: fish kills or the absence of fish; refusal of cattle to drink river water; corrosion of farm machinery which fords the river; cloudy or murky appearance of the river; and muck on the bottom of the river and on the banks following high water.

Pine Grove, Virginia

In 1950 an industrial consultant inquired regarding the suitability of the quality of the North Fork Holston River in the Pine Grove to Mendota section of the river as a source of supply for a synthetic liquid fuel plant, and asked whether there were any plans for reduction of calcium and sodium chloride wastes. In reply, the Executive Secretary of the Virginia Water Control Board said that the water was not suitable as a potable and industrial source, and that there were no specific plans for improvement at that time. The plant was not located in this area.

Mendota, Virginia

It has been claimed by a local citizen that two industrial plants were lost to this area because of the unsuitable quality of the river water. It is possible that one of these was the synthetic liquid fuel plant referred to above.

Washington County, Virginia

In 1948 the Washington County Wildlife Conservation Association claimed that an industrial plant had been lost to Washington County because of the unsuitable quality of North Fork Holston River water.

Scott County, Virginia

In 1947, a consultant requested information from the Virginia Department of Public Health regarding the suitability of the North Fork Holston River as a source of domestic water supply for a southeastern area in Scott County. The request was turned over to the Executive Secretary of the Virginia Water Control Board, who replied that the river was not suitable as a source of domestic water supply.

North Kingsport Utilities District, Kingsport, Tennessee

This utilities district serves water to about 1,500 domestic customers. The consultant who planned the water system has stated that he would have used the North Fork Holston River as the source of supply if the quality had been suitable. It was necessary instead to develop local springs as the source of supply. The combined capacity of the springs is limited and it is anticipated that water requirements within the next five to six years may exceed the present supply. No other known natural sources of water are available for this utilities district.

Kingsport, Tennessee

In making a preliminary survey of available sources of water for the Kingsport municipal supply, the consulting sanitary engineer concluded that the North Fork Holston River was desirable as a source from the standpoint of topography, flow, and sanitary water quality. After having a sample of the river water analyzed, he decided that its mineral content rendered it unsuitable, and designed the water system to use instead the South Fork Holston River as the source of supply. This stream was selected in preference to the North Fork in spite of the existence of several communities and manufacturing plants which were discharging untreated sewage and industrial wastes to the South Fork Holston River or its tributaries upstream from Kingsport.

Holston Ordnance Works, Kingsport, Tennessee

The Holston Ordnance Works, Plant B, was established on the west side of the Holston River a short distance below Kingsport during World War II. Although the Holston River would have been the logical source of water for the large quantities of steam necessary for this operation, the consulting engineer on water supply concluded that the mineral quality of the Holston River was unsuitable. Hardness was the most deleterious constituent.

In order to obtain boiler feed water of more suitable quality, a dike system was installed between the confluence of the North and South forks of the Holston River to keep the North and South fork waters separate to the Holston Ordnance Works intake. In spite of the relatively high load of organic pollution discharged to the South Fork Holston River by Kingsport and its industries, it had been decided that the South Fork water would be more suitable for

boiler feed water than would the mixture of water from the two streams. In order to obtain South Fork water after installation of the dike system, it was necessary to construct a submerged intake line under the river to the east side of the stream.

Following the war years, the plant was placed on a stand-by basis and partial operation was not resumed until 1951. During the intervening period, the dike had deteriorated and allowed interchange of water between the North and South forks. An attempt was made to operate without repairing the dikes until 1953. During this two-year period hardness at the water plant intake often reached levels of 700 to 800 mg/l. The water softening equipment, with a capacity of 128,000 gallons per hour, was designed to treat water with a maximum of 145 mg/l of hardness. On one occasion the hardness was so high the overloaded softeners required nearly a month's supply of salt to regenerate the softeners during a two-day period. The available supply of salt was exhausted and in order to continue the plant in operation it was necessary to purchase table quality salt from all available dealers in the surrounding area.

In 1953 the dike was repaired and has been maintained since that time. No abnormal problems attributable to excessive hardness of the water supply have arisen since then.

Total capital costs necessary to obtain South Fork Holston River water have been:

Initial installation of dike	$15,643.00
Replacement of dike (1953)	28,750.00
Intake line	105,047.00
Total capital costs	$149,440.00

In addition, it has been necessary to make an engineering survey to determine where additional water could be obtained if the plant were required to go into full production. This was necessary because the South Fork Holston River at times does not provide enough flow to meet the needs of the plant at full production. The cost of the consultant's report on this problem

was about $30,000.00. The report suggested three possible solutions which would involve capital costs in the range of $130,000.00 to $227,000.00. The plan requiring the lowest capital cost of $130,000.00 would have the highest annual operating cost of about $1,000,000.00 per year.

An additional cost to the Holston Ordnance Works has been $5,000.00 per year for maintenance of the dike during the last seven years, for a total of $35,000.

American St. Gobain Corporation - Greenland Plate Glass Plant

This company has started the construction of a large glass plant on the Holston River between Rogersville and Surgoinsville, Tennessee. Plans are to use the Holston River as a source of water supply. The chloride content of the Holston River water presents a potential need for costly water treatment to assure satisfactory water quality.

A representative of the company has stated that the chloride content of the river will make the glass grinding operation difficult to control uniformly and estimated that the added cost of constant attention and adjustment necessary may equal $7,000.00 to $8,000.00 per year, plus the possibility of an indeterminate production loss.

If peak chloride concentrations should prove to be high enough to necessitate de-mineralization for the grinding operation, it is anticipated that de-mineralizing equipment will cost about $40,000.00 and that operation of the equipment will cost $148,000.00 per year.

There are other processes where chlorides may prove to be objectionable. If it should become necessary to de-mineralize the entire water supply it is estimated that the cost would be $730,000.00 per year initially, and with expanded production this could increase to $1,460,000.00 per year.

Rogersville, Tennessee

A past president of the Rogersville Chamber of Commerce has stated that three prospective plants have been lost in this area because of unsatisfactory water quality in the Holston River. At least one of these was stated to have a potential employment of 1,000 to 1,200 persons.

The Executive Secretary of the Tennessee Stream Pollution Control Board has stated that another large company was interested in a plant site in this area but lost interest after obtaining information on the water quality of the Holston River.

TVA John Sevier Steam Plant, Rogersville, Tennessee

When this plant was in the design stage, both the consultant on water supply and the manufacturer of softening equipment advised TVA design personnel that the Holston River water would not be suitable for boiler feed water at times when peaks of total dissolved solids exceeded 650 mg/l, or when total anions and cations exceeded 500 to 700 mg/l. It was determined that these conditions were exceeded when the conductivity of the river water exceeded 550 micromhos.

In order to meet this problem the TVA impounded a small creek near the plant and installed continuous recording conductivity equipment on the river, and pumps to deliver river water to the impoundment. Water is taken from the Holston for boiler feed make-up when the conductivity of water from the river is less than 550 micromhos. Water also is pumped from the river to the impoundment, when needed, when the conductivity is below this level. When conductivity of river water exceeds 550 micromhos, boiler feed make-up water is drawn from the impoundment.

In spite of these precautions, it has been necessary on three occasions since 1956 to call for special releases of water from Fort Patrick Henry Reservoir on South Fork Holston River to provide dilution for the excessively mineralized water. Recently the level of the impoundment which serves as the auxiliary source has been increased by two feet. It is hoped that the additional storage will eliminate the necessity for the special releases from Fort Patrick Henry Reservoir.

The capital cost of the necessary installation was $50,000.00 and annual operating cost has been estimated at $500.00 per year.

Morristown, Tennessee

This town obtains water from the Holston River, a well, a spring, and a small creek. About 75 to 80 percent of the water is pumped from the Holston River.

The old conventional coagulation, sedimentation, rapid sand filtration and disinfection treatment plant is being replaced in stages. Plans are to complete replacement in about three years. The final plant will incorporate provisions for softening. The sanitary engineering consultant has stated he would not recommend facilities for softening if the hardness of the raw water source were reduced by 90 to 100 mg/l.

It is estimated that the additional facilities necessary for softening will involve a capital cost of $35,000 to $40,000.00. In addition, it is estimated that annual operating costs to remove the hardness caused by calcium chloride from the Olin Mathieson plant will be about $11,000.00 per year.

It is estimated that the cost of extra soap and synthetic detergents used by the Morristown municipal supply domestic consumers, because of the Olin Mathieson wastes, is about $33,000.00 per year when hardness is equivalent to that of the 1952-1956 period. Other less tangible losses bring the total cost to the water consumers to an estimated $59,000.00 per year.

Northeast Knox Utility District, Knoxville, Tennessee

This relatively new utility district takes water from the Holston River a few miles above its mouth. It is estimated that the extra cost of soap and synthetic detergents plus intangible losses borne by the 1700 consumers of this supply, because of hardness added by the Olin Mathieson wastes, is about $4,900.00 per year.

East Knox Utility District, Knoxville, Tennessee

This utility district takes water from the Holston River a few hundred yards below the intake for the Northeast Knox Utility District. The East Knox Utility District also has about 1700 consumers and it is estimated that they also are subjected to excessive costs of $4,900.00 per year because of Olin Mathieson wastes.

Knoxville, Tennessee

The municipal water supply for Knoxville takes water from the Tennessee River about three miles below the confluence of the Holston and French Broad Rivers. The system supplies water to about 175,000 domestic customers plus numerous commercial and industrial users.

It is estimated that extra soaps and synthetic detergents used by these consumers, when the hardness added by the Olin Mathieson wastes is equivalent to that of the 1952-1956 period, cost $110,000.00 per year. Added intangible losses bring the total cost to $198,000.00 per year.

At least two of the industries using the Knoxville municipal water supply have stated that chlorides caused interference with their processes. One of these claims that excessive chlorides caused spots on the brass products manufactured by the plant. The other industry stated that excessive chlorides interferred with their process for silvering mirrors. No estimates of costs to these two plants are available.

Two of the numerous commercial users of water from the municipal supply have estimated the increased cost of softening due to Olin Mathieson wastes to be a total of $2,150.00 per year.

Lenoir City, Tennessee

The municipal supply for Lenoir City is taken from the Tennessee River a short distance below Fort Loudoun Dam. The quality of water at this point is essentially the same as that used by the Knoxville water supply. It is estimated that the cost of extra soap and synthetic detergents, and intangible losses borne by the 7,500 customers of this municipal supply because of Olin Mathieson wastes is $8,500.00 per year.

SUMMARY AND CONCLUSIONS

The Olin Mathieson Chemical Corporation plant at Saltville, Virginia, discharges wastes containing large quantities of calcium and sodium chloride which are produced in the manufacture of soda ash by the ammonia-soda process. During the period 1952 through 1956, the wastes contained an average of 1,670,000 pounds per day of calcium chloride and about 1,245,000 pounds per day of sodium chloride. Hardness, due to the calcium chloride plus a small quantity of magnesium compound, was equivalent to 1,590,000 pounds per day of hardness as calcium carbonate. Total chlorides were 1,841,000 pounds per day and total sodium was 478,000 pounds per day.

As far downstream as Knoxville, Tennessee, about 225 river miles below Saltville, these wastes contributed an estimated 26 percent of the total hardness, 84 percent of the chlorides, and 57 percent of the sodium. Percentages of these constituents in the North Fork Holston River, near the Virginia-Tennessee state line, were about 80 percent of the total hardness and 99 percent of the chlorides and sodium. In the Holston River the percentages were about 40 percent of the hardness, 94 percent of the chlorides, and 84 percent of the sodium.

In the North Fork Holston River, for several miles below Saltville, it has been reported that the Olin Mathieson wastes have: reduced fish through both kills and decreased propagation; interferred with agricultural pursuits, including stock watering and the transportation of farm equipment across the river; and imparted a milky turbidity to the river, and covered its bottom and banks with muck.

The additional hardness, imparted to downstream municipal water supplies by the wastes, has caused inconvenience to water consumers and has cost them at the 1952-1956 concentrations, an estimated $275,000.00 per year in added soap and synthetic detergent usage, and associated intangible losses.

Because of the added hardness, downstream industries have had to bear capital cost of at least $200,000.00 to combat the hardness. In prospect other total capital costs in the range of $210,000.00 to $307,000.00 may be spent by one municipality and two industries.

A new industry starting construction of a plant on the Holston River is faced with possible annual water treatment costs to combat chlorides estimated to be in the range of $148,000.00 to $1,460,000.00.

At least three areas have been denied the use of North Fork Holston River water as the preferred source for municipal supplies. Two of these areas are in Tennessee.

On the basis of this investigation, it would appear that the greatest loss to the region adjacent to the North Fork Holston River and the Holston River has been the loss of industries that found the water of these two streams unsuitable for their uses. Reports indicate that water quality has been an important factor in adverse decisions involving at least seven plants for which sites along the North Fork Holston River and Holston River were considered.

It is evident that pollution of the North Fork Holston River by the Olin Mathieson Chemical Corporation constitutes pollution of interstate waters subject to abatement under the Federal Water Pollution Control Act, as such pollution endangers the health or welfare of persons in a state other than that in which the discharge contributing to such pollution originates.